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**SPORT DEVICE**

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> Background of the Invention

The invention relates to a frame for a sporting device for coupling to a shoe, such as a ski which is slidable or rollable by means of wheels, in particular a cross-country ski, or a skate frame for an ice-skate or roller-skate, which frame comprises:

an upper sub-frame with means for coupling to a shoe to be worn by a user;

a lower sub-frame which is coupled via a pivot mechanism to said upper sub-frame for pivoting in a main plane and which is provided with or adapted to be provided with a runner or wheels; and

resetting spring means for urging both sub-frames toward each other.

Such a frame is known for a skate and has been commercially available for many years under the name tumble skate ~~"tumble skate"~~.

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The object of such a variable construction is to make the force exerted by the skater on the ice or the ground as great as possible so as to thereby maximize the effectiveness of muscle power and the speed to be thus achieved.

It has been found that while the known skate has the advantage of a very simple construction it is not able to realize the stated objective.

An important cause of this technical deficiency of the known skate lies in the fact that both sub-frames are connected for mutual pivoting in a zone located in the region of the tip of the shoe. While a large pivot angle can thereby be realized, the force to be exerted has an effective point of engagement located so far from the front of the foot that an effective force transfer is illusory.

The invention has for its object to embody a skate frame such that the effectiveness of the force

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transfer is made as great as possible, on the one hand by choosing, optionally in variable manner, the effective point of engagement of the thrust forces during skating on the basis of physiological and ergonomic considerations and on the other by allowing the user to use the calf-muscles during skating, which is not the case with known, non-variable skates and which is the case to only very small, almost negligible extent with the described known tumble skate.

What is of great importance is that the frame allows the possibility of bending the foot in a manner which is similar to that in a walking movement. This is important for a stable thrust and for the best possible effective use of the relevant muscles. The prior art skates are not capable of this.

Summary of the Invention

In respect of the above the frame according to the invention has the special feature that the sub-frames are mutually pivotable and translatable in the said main plane.

A specific embodiment has the feature that the sub-frames form part of a mechanism comprising at least four mutually pivotable and/or translatable (optionally theoretical) rods. It must be appreciated that the term "rod mechanism" as used above must be interpreted in a broad sense. A translation in a particular direction can for instance be seen as a rotation of an infinitely long rod extending in transverse direction of the translation.

The upper sub-frame can be embodied such that the position of the shoe relative to this upper sub-frame is adjustable. Longitudinal adjusting means can be present for this purpose.

A frame is recommended which has only one degree of freedom.

A degree of freedom is defined as a movement possibility of a mechanism or a connection which can be designated with only one variable, for instance the pivot angle an element can make round a hinged connection. In this case the degrees of freedom are defined in relation

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to the relative movement possibilities of the upper sub-frame and the lower sub-frame.

The other aspect of the invention relates to the fact that the frame has a (real or virtual) pole path. A pole path is the set of instantaneous centres of rotation or poles of the upper sub-frame relative to the lower sub-frame. Attention is drawn to the fact that for a well-defined pole path the frame may only have one degree of freedom.

The embodiment is recommended in which the pole path is substantially straight.

This latter variant can advantageously have the special feature that the pole path extends substantially horizontally.

At least for sporting devices with foot bending, this latter variant is preferably embodied such that the pole path extends between a starting position under the ball of the foot of a user in the rest position of the frame, and an end position under the big toe of the user in the extreme outward pivoted position of the frame.

The best results are obtained with an embodiment in which at constant relative angular speed of the sub-frames the speed of the pole along the pole path increases from the starting position to the end position. In preference the speed is initially substantially constant while the speed increases toward the end of the path.

A specific variant has the special feature that a frame is a member of the family in accordance with the table below, in which the first number designates the number of (optionally theoretical) rods, p1 designates the number of connections with one degree of freedom, p2 designates the number of connections with two degrees of freedom and # designates the presence of a well-defined pole path and therewith the suitability for a sporting device with foot bending:

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| Family/member | Figure | p1 | p2 | suitable |
|---|---|---|---|---|
| 2 / 1 | 8 | 0 | 2 | # |
| 3 / 1 | 9 | 2 | 1 | |
| 3 / 2 | 10 | 1 | 1 | |
| 3 / 3 | 11 | 0 | 1 | |
| 4 / 1 | 12 | 4 | 0 | # |
| 4 / 2 | 13 | 4 | 0 | # |
| 4 / 3 | 14 | 3 | 2 | # |
| 4 / 4 | 15 | 2 | 4 | # |
| 4 / 5 | 16 | 1 | 6 | # |
| 4 / 6 | 17 | 0 | 8 | # |
| 5 / 1 | 18 | 5 | 1 | # |
| 5 / 2 | 19 | 4 | 3 | # |
| 5 / 3 | 20 | 3 | 5 | # |
| 5 / 4 | 21 | 2 | 7 | # |
| 5 / 5 | 22 | 1 | 9 | # |
| 5 / 6 | 23 | 0 | 11 | # |
| 6 / 1 | 24 | 7 | 0 | # |
| 6 / 2 | 25 | 6 | 2 | # |
| 6 / 3 | 26 | 5 | 4 | # |
| 6 / 4 | 27 | 4 | 6 | # |
| 6 / 5 | 28 | 3 | 8 | # |
| 6 / 6 | 29 | 2 | 10 | # |
| 6 / 7 | 30 | 1 | 12 | # |
| 6 / 8 | 31 | 0 | 14 | # |

A preferred choice of the available mechanisms provides a frame in which the frame comprises seven, eight, nine or ten pivot axes.

Probably the best compromise in respect of kinematic requirements, weight and simplicity is realized with a frame in which the frame comprises seven pivot axes.

All the stated criteria are satisfied with an embodiment in which the frame is constructed as according to figure 24 and (at least the relative) dimensioning according to figure 35.

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In order to be able to withstand the very great forces which occur the frame must be mechanically very strong. It is particularly important for the frame to have torsional stiffness.

The following requirements can further be made of the frame for use in a skate with foot bending:

* the maximum height is about 30 mm. This maximum is determined by the space between the support tube for the runner and the shoe.

* the maximum length is about 150 mm. The heel support forms the criterion in this respect.

* the shafts forming the pivot axes may not be closer together than roughly 10 mm, since problems of strength might otherwise occur.

a Brief Description of the Several Views of the Drawings

The invention will now be elucidated with reference to the annexed drawings. In the drawings:

C figures 1A, B and C are prior art and show schematically a known tumble skate in three respective pivoting positions;

C figures 2A, B and C are prior art and show a possible variant of the known tumble skate, wherein the hinge is displaced to the rear, or under the ball of the foot;

C figures 3, 4 and 5 are prior art and show in schematic side view three possible connections in the flat plane with one degree of freedom;

C figure 6 is prior art and shows a connection in the flat plane with two degrees of freedom;

figure 7a shows schematically the contact between two profiles;

figure 7b shows a further developed embodiment of the connection of figure 7a;

figures 8-31 are schematic views of the family members of the table of claim 9;

figures 32A, B show perspective views in pivoted situation of a preferred frame as according to figure 24 (family member 6/1);

figures 33A, B show the skate of figure 32, partly in side view, partly in lengthwise section,

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respectively in the rest position and the extreme pivot position of 48°;

figure 34 is a diagram elucidating the structure of the skate according to figures 32 and 33;

figure 35 is a graphic representation in cartesian coordinates of the locations of the pivot axes; and

figure 36 shows the change in position in X and Y direction of the pole as a function of the pivot angle of the skate according to figures 32-35.

Detailed Description of the Invention

Figures 1A, 1B and 1C show schematically a known tumble skate 1 in respectively a rest position, an intermediate pivot position and an extreme pivot position. The skate comprises a shoe 2, an upper sub-frame 3 connected to the sole thereof, a lower sub-frame 5 in tubular form connected to sub-frame 3 at the front via a hinge 4 and a runner 6 arranged on sub-frame 5.

Figure 2 shows a possible variant of skate 1. This skate 9 is modified in the sense that the axis of the hinge 4' lies further to the rear than that of hinge 4 according to figure 1. This could result in an improvement in respect of force transfer. The hinge 4' effectively lies roughly under the ball of the foot of a user. While a small improvement in the effectiveness of the force transfer can hereby be realized in combination with a simple construction, this embodiment has the drawback that the pivot angle is necessarily limited. This becomes particularly clear with reference to figure 2C.

It is noted generally that, where possible and appropriate, the same components are designated with the same reference numerals. This applies not only to identical components but also, and particularly, for functionally corresponding components.

Figure 3 shows a connection between two elements 7, 8 (corresponding respectively with upper sub-frame 3 and lower sub-frame 5). This connection in the flat plane has only one degree of freedom.

Figure 4 likewise shows a connection between two elements 7, 8 with one degree of freedom. As the figure shows, these elements are mutually connected by a rectilinear guide so that they have only a degree of freedom of translation.

Figure 5 shows a connection between elements 7 and 8 comprising a curve guide which effectively implies a hybrid of the hinge connection of figure 3 and the rectilinear guide of figure 4. It will be apparent that, despite there being only one degree of freedom, there is both a translation and a rotation.

Figure 6 shows an embodiment of a coupling between elements 7 and 8 with two degrees of freedom. This is a hinge in a guide path.

Figure 7A shows the coupling between two profiles with both a translation and rotation degree of freedom.

The skate 10 according to figure 7B comprises two mutually co-acting gear racks 11, 12 which form part of the respective elements 7, 8. It will be apparent that due to a displacement from the rest position designated with 2, 3 of shoe and upper sub-frame to the pivot position designated with 2', 3' both a rotation and a translation occur, wherein the centre of rotation follows a path corresponding with the rack 12. This is therefore a real pole path.

For a well-defined pole path the frame may have only one degree of freedom. It is pointed out once again that the invention relates exclusively to the degrees of freedom of the above mentioned elements 7 and 8, corresponding respectively to an upper sub-frame, which is or can be coupled to a shoe, and a lower sub-frame to which a runner, wheels, a ski-beam or the like is/are or can be connected.

Figures 8-31 show the family members as stated in the table included above.

Attention is drawn to the fact that, as already stated, the presence of a pole path is required for the

devices applicable within the scope of the invention for sporting devices with foot bending. The embodiments of figures 9, 10 and 11 therefore do not meet this requirement.

Of particular importance is the embodiment according to figure 24, family member 6/1. This embodiment comprises six rods and seven pivot axes. The principle sketched in figure 24 will be discussed below as a concrete example with reference to the preferred embodiment of the invention, i.e. with reference to figures 32A, B, 33A, B, 34, 35 and 36.

In respect of the table shown and the associated figures 8-31 it is noted that, in addition to the above mentioned families of rod mechanisms, families can also be formulated with more than six rods/elements per mechanism.

For each hinge connection in the above mentioned families a rectilinear guide can also be chosen.

For each hinge in a guide path a contact can also be chosen between two profiles, wherein it is noted with reference to figure 7A that load is not possible in all directions.

For each hinge in a guide path a curved guide path can also be chosen, which results in the pole path of an element being influenced.

The twenty-four mechanisms according to the figures 8-31 and their variants as according to the comments above are not all equally suitable to satisfy the stringent requirements which can be made of the pole path of an element. The elements which are in principle suitable are designated with # in the table.

Rectilinear guides, curve guides and pivot guides are less capable in practice of holding the mechanism in the defined plane than simple hinges.

Experience with families of systems as specified above has demonstrated that with four hinges the stringent requirements for kinematics, weight,



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simplicity and well-defined pole path cannot be met. The requirements can be met in very close approximation with seven hinges, while with ten hinges the requirements can be satisfied virtually perfectly.

Partly with a view to a low weight, simplicity of construction and price, the mechanism according to figure 24, family member 6/1, is currently considered the most suitable. The following figures all relate thereto.

Figures 32A and B show a skate 13 based on the principle outlined in figure 24. Corresponding with figure 24, the upper sub-frame is designated with a double reference 3, 7 in order to make clear the functional relation between the upper sub-frame according to figures 1 and 2 and the element 7 of figure 24. Similarly, the lower sub-frame is designated with 5, 8. It should be appreciated in this respect that the lower sub-frame 5, 8 is connected by screws to a tubular frame part 14 which bears the runner 6.

In figures 32A and B, 33A, B and 34 are shown only the seven hinges A, B, C, D, E, F and G. The six rods are designated, insofar as necessary, with the relevant indications of these hinges. It will be apparent that the rod A B C is formed by the lower sub-frame 5, 8, 14, including the tubular frame part 14. The upper sub-frame G F is coupled to the sole of the shoe 2.

Figures 33A and B in particular show clearly the diverse positional changes during pivoting of the diverse rods and their hinges. Figure 34 shows the position of figure 33A on large scale. Also drawn herein are the displacements of the hinges D, C, G and F during pivoting of the sub-frame 3, 7.

The above discussed pole path of sub-frame 3, 7, or the rod G F, runs, in accordance with the requirements to be made, practically entirely horizontally from below the ball of the foot to below the big toe of a user, provided the dimensioning specifications are complied with as shown in figure 35 and the table included therein.



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In figure 35 the position of each hinge A, B, C, D, E, F, G is indicated in a cartesian coordinate system. Attention is drawn to the fact that the X coordinate of the hinge B can have the indicated value or can display a certain positive deviation, depending on the shoe size of the user. Three shoe sizes can for instance be chosen, wherein the positive deviation relative to the given basic value amounts respectively to about 1.3 and 2.6 mm.

Attention is drawn to the fact that the origin of the coordinate system according to figure 35 is chosen randomly on the rear of the lower sub-frame 5, 8. Any other point of this sub-frame 5, 8 could have served as reference, for instance the hinge A. The dimensioning of the whole system A-G can be modified relative to for instance this hinge A, provided the ratios are preserved.

Figure 36 shows in parameter presentation the pole path of the upper sub-frame 3, 7 relative to the lower sub-frame 5, 8. Shown horizontally is the pivot angle in degrees while in vertical direction is shown the positional change of the pivot centre in respectively X direction ($\Delta x$) and Y direction ($\Delta y$). The graph of figure 36 shows that the change $\Delta y$ in vertical direction amounts to a few millimetres and reaches roughly zero at the end of the pivot path corresponding with a pivot angle of about 48°.

The positional change of the pole in horizontal direction is designated with $\Delta x$. The speed is practically constant up to a of pivot angle of about 35°. After this distance the pole accelerates up to the end position.

Attention is once again drawn to the fact that at a pivot angle of zero the pole is situated roughly under the ball of the foot and at the end is situated under the big toe.

Attention is drawn to a resetting spring 115 embodied as helical torsion spring (see figure 33A, B) which is arranged round the shaft of hinge A and exerts a resetting force between the rods ABE (see figure 24) and

AD such that sub-frame 3, 7 is thereby urged to its rest position as shown in figure 33A where a heel element 15 can rest in a tapering stopper surface 16 which forms part of the lower sub-frame 5, 8 and which is covered with an elastic material to thus form a soft stop.

The lower sub-frame 5, 8 can be manufactured by starting from an extruded profile from which parts are removed selectively. All rods of the frame can very suitably be manufactured from aluminium. This material combines a low weight with sufficient strength. The hinges can be manufactured in per se known manner from very wear-resistant materials and combinations thereof.

Attention is drawn to the fact that the resetting spring means are not shown in all the figures. These can be very suitably embodied as a helical draw spring, a torsion spring or a spiral spring. A plurality of springs may also be active in the rod mechanism. The bias and stiffness of the spring means are determined by two considerations. On the one hand, during the inactive phase of a skating stroke, the lower sub-frame must be carried as quickly as possible to the upper sub-frame. On the other hand, the resetting force must not be so great that too considerable a part of the available force is absorbed by the spring means.

It is noted that the comparatively large pivot angle to be realized according to the invention of more than, optionally considerably more than, 20° corresponds with a natural unrolling of the movement of a foot.

The skate according to the invention makes optimal use of the possible rotation of the foot round the ankle. This mobility is designated "plantar flexion" and is essential for a good force transfer.

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On the basis of the above very briefly stated considerations it can be anticipated that the skate frame according to the invention can result in essential speed increases.

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